



Maricopa County Air Quality Department

1001 North Central Avenue
Phoenix, Arizona 85004

A multi-objective assessment of an air quality monitoring network using environmental, economic, and social indicators and GIS-based models

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Background

- After the Network Assessment requirement was introduced in 2006, it was assigned to me.
- I found many different methods for designing/assessing a network.
- I wanted to bring these methods together for a comprehensive evaluation.
- Eventually this plan became part of my dissertation research.



Original Network Assessment

- The original or ‘official’ assessment was completed in 2010 for the Maricopa County Air Quality Department.
- It covered the time period 2005-2009.
- It included sections for all six of the criteria pollutants and historical background on our monitoring sites.





Article for the Journal of Air & Waste Management

- Based upon the original network assessment, but only includes the pollutants O_3 and PM_{10} .
- Includes modified methods such as a more stringent indicator weighting system.
- Adds a sustainable development score to the indicators.



Assessment Design

- 3 Phases:
 - **Phase I:** a series of indicators score stations in the current monitoring network.
 - **Phase II:** spatial models indicate new areas that would benefit from additional stations.
 - **Phase III:** Recommendations for the network.



Additional Aspects

- Phase I indicators are classified by a sustainable development objective:
 - Environmental indicators are related to the emissions and concentrations of sources and air pollutants, respectively;
 - Social indicators are related to population and sensitive receptors;
 - Economic indicators are related to the cost-effectiveness of stations within the AQMN .



Additional Aspects

- Indicators that emphasize environmental justice issues
 - i.e., it includes analyses to determine whether distinct populations are experiencing a disproportionate amount of risk from air pollution.



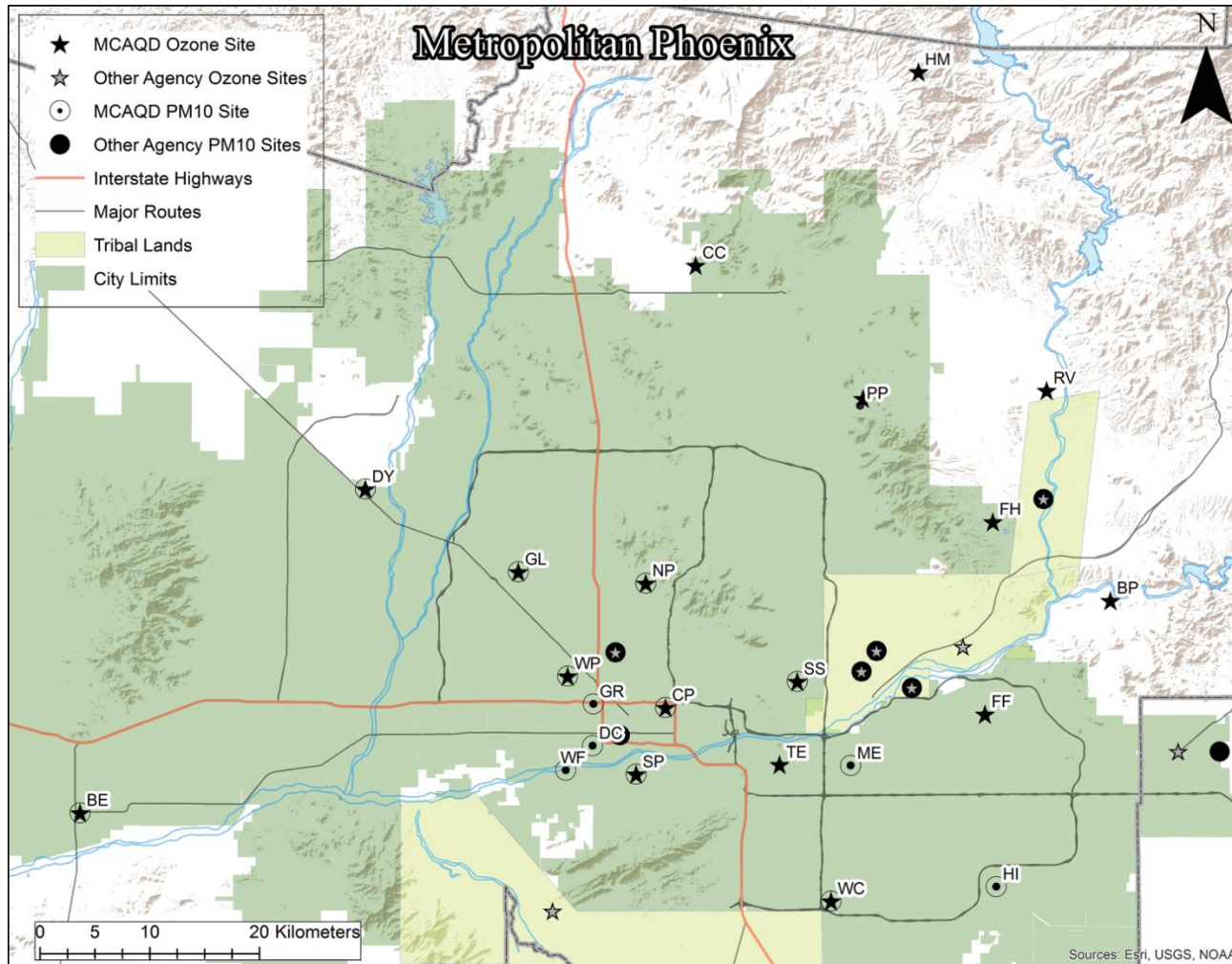


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METHODS

Methods- Study Area



Methods-Data Sources

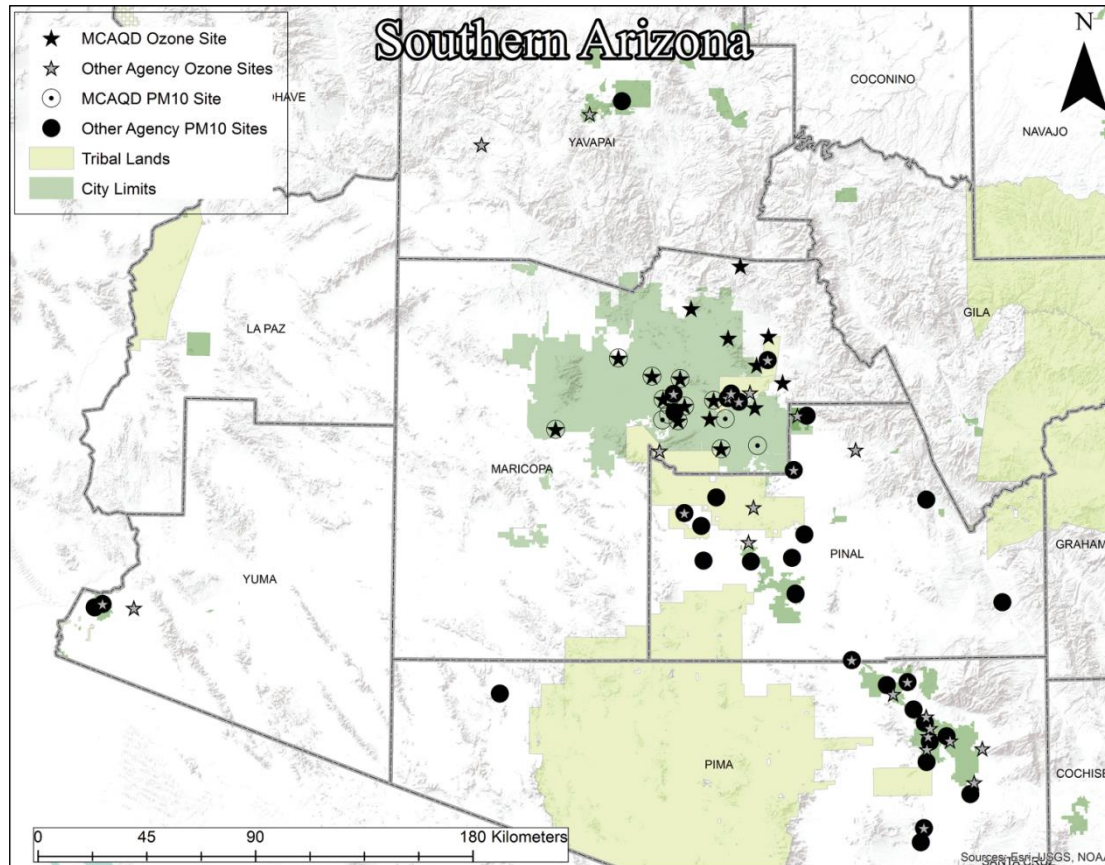


Table 2. Agencies providing data and the number of monitoring stations used within this study

Agency	Type of agency	Number O ₃ stations	Number PM ₁₀ stations
Maricopa County Air Quality Department	Local (County)	17	14
Arizona Department of Environmental Quality	State	6	8
Fort McDowell Yavapai Nation	Tribal	1	1
Gila River Indian Community	Tribal	2	1
National Park Service	Federal	1	0
Pima County Department of Environmental Quality	Local (County)	9	8
Pinal County Air Quality Control District	Local (County)	5	13
Salt River Pima-Maricopa Indian Community	Tribal	4	3

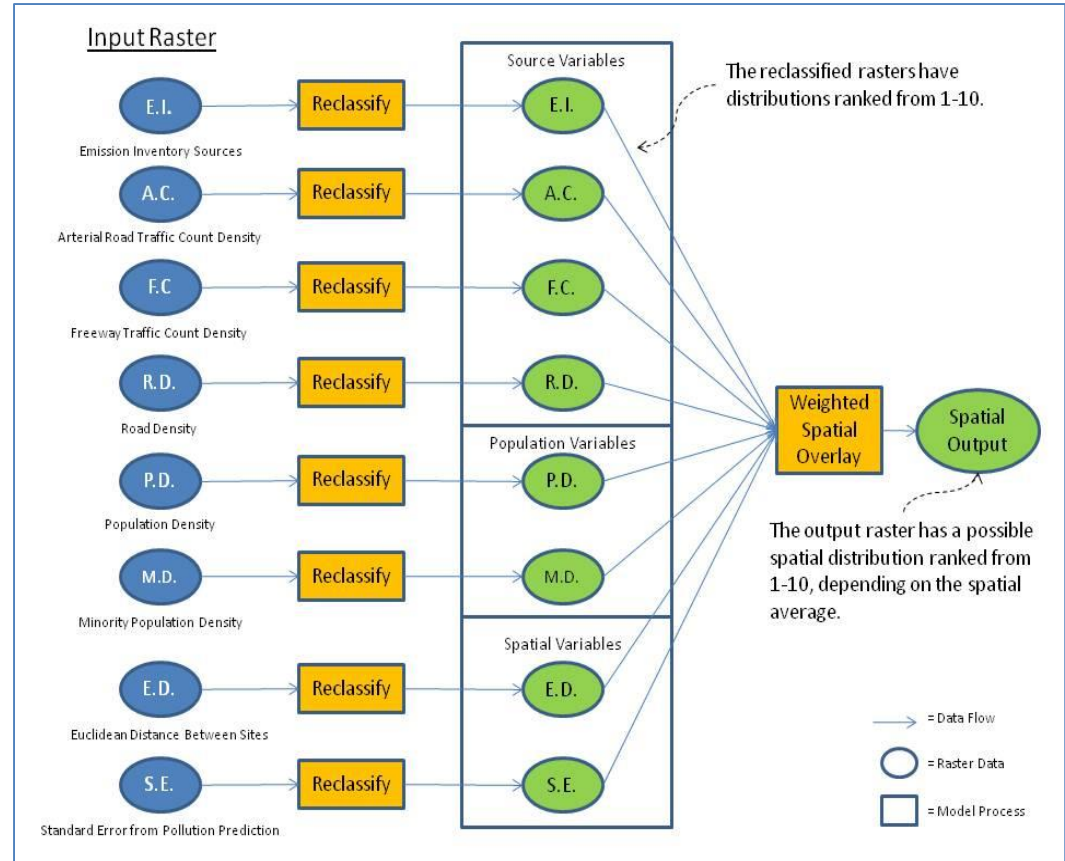
Phase I Indicators

#	Indicator	Sustainability Group
1	Measured Concentrations	Environmental
2	Deviation from the NAAQS	Environmental
3	Area Served	Environmental/Social
4a	Emissions Inventory	Environmental
4b	Emissions Inventory -Predicted Ozone	Environmental
5	Traffic Counts	Environmental
6	Monitor-to-Monitor Correlation	Environmental/Economic
7	Removal Bias	Environmental/Economic
8	Population Served	Social
9	Environmental Justice-Minority Population served	Social
10	Trends Impact	Social/Economic
11	Number of other Parameters Monitored	Economic



Phase II Indicators

#	Indicator	Category
1	Emissions Inventory Point Sources	Source-Oriented
2	Arterial Road Traffic Count	Source-Oriented
3	Freeway Traffic Count	Source-Oriented
4	Road Density	Source-Oriented
5	Population Density	Population-Oriented
6	Minority Population Density	Population-Oriented
7	Euclidean Distance between Sites	Spatially-Oriented
8	Standard Error from Predicted Pollution	Spatially-Oriented



Weights

(a)

#	Phase I Indicator	Sustainability Descriptor	O ₃ Weight	PM ₁₀ Weight
1	Measured Concentrations	Environmental	13.03%	13.81%
2	Deviation from the NAAQS	Environmental	9.32%	9.48%
3	Area Served	Environmental/Social	8.12%	8.48%
4	Emissions Inventory	Environmental	7.78%	11.59%
4b	Emissions Inventory -Predicted Ozone	Environmental	9.38%	N/A
5	Traffic Counts	Environmental	8.12%	8.49%
6	Monitor-to-Monitor Correlation	Environmental/Economic	7.12%	6.32%
7	Removal Bias	Environmental/Economic	8.27%	7.85%
8	Population Served	Social	8.32%	9.82%
9	Environmental Justice-Minority Population Served	Social	7.22%	9.22%
10	Trends Impact	Social /Economic	8.82%	10.08%
11	Number of Other Parameters Monitored	Economic	4.51%	4.89%
		Total	100.0%	100.0%

(b)

#	Phase II Indicator	Category	O ₃ Weight	PM ₁₀ Weight
1	Emissions Inventory Point Sources	Source-Oriented	13.3%	20.0%
2	Arterial Road Traffic Count	Source-Oriented	8.9%	9.0%
3	Freeway Traffic Count	Source-Oriented	8.4%	8.4%
4	Road Density	Source-Oriented	9.9%	10.0%
5	Population Density	Population-Oriented	17.6%	16.3%
6	Minority Population Density	Population-Oriented	13.6%	12.9%
7	Euclidean Distance Between Sites	Spatially-Oriented	13.4%	11.1%
8	Standard Error from Predicted Pollution	Spatially-Oriented	15.0%	12.2%
		Total	100.0%	100.0%





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RESULTS

Phase I Results-PM10

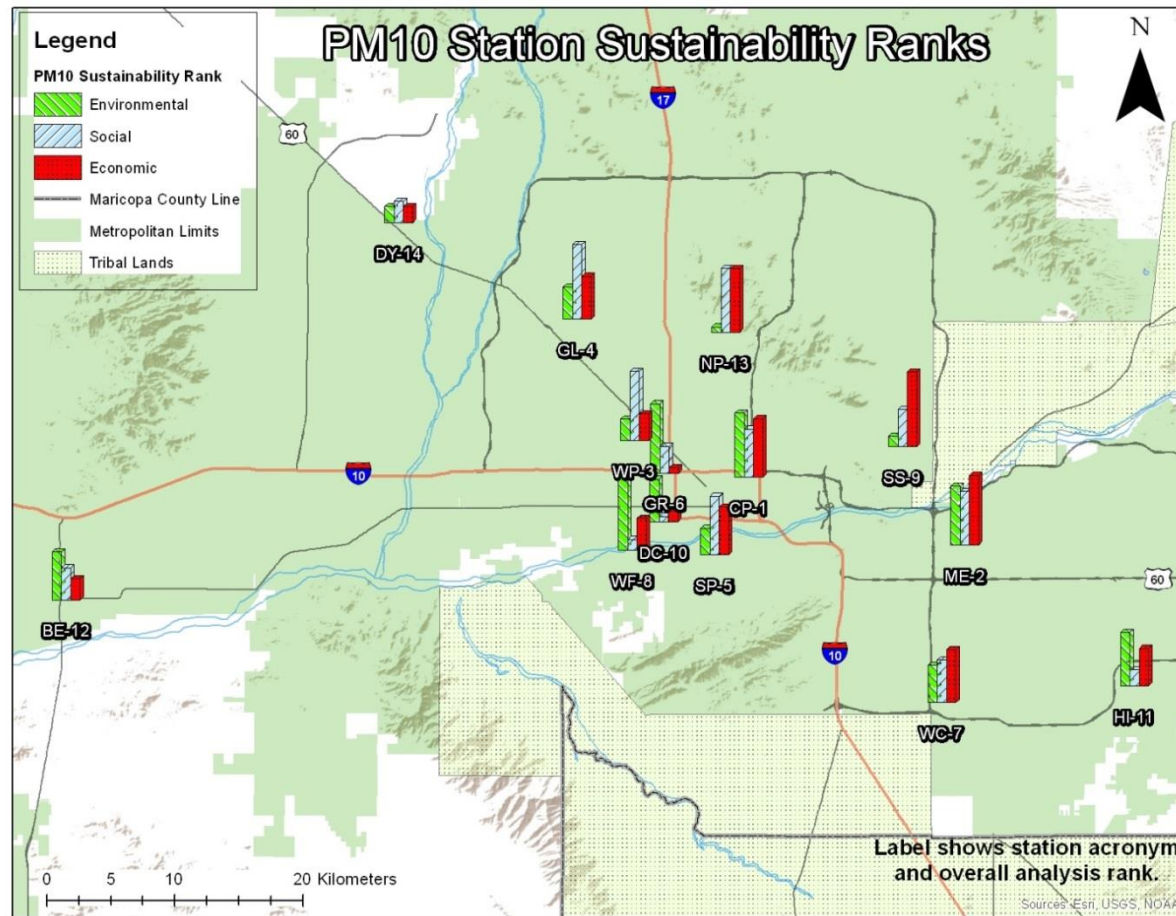
Raw Indicator Scores													
Site	1	2	3	4a	5	6	7	8	9	10	11	Average	RANK
BE	13	2	14	4	1	11	-	3	8	1	10	6.70	12
CP	8	13	3	9	14	4	4	6	10.5	13.5	12.5	8.86	1
DC	12	3	1	14	7.5	3	7	1	12.5	5	1	6.09	13
DY	5	9	13	5	2	6.5	6	9	1	2	6	5.86	14
GL	4	8	10	11	7.5	6.5	5	14	7	11.5	6	8.23	4
GR	9	12	2	13	13	1.5	3	2	14	6.5	6	7.45	7
HI	11	6	9	2	6	13	11	8	2	4	2.5	6.77	11
ME	2	5	6	12	12	14	10	12	9	8.5	6	8.77	2
NP	1	4	12	3	5	12	8	13	3	8.5	10	7.23	9
SP	10	11	7	8	4	6.5	2	5	10.5	13.5	10	7.95	5
SS	3	7	5	6	10	6.5	9	7	4	11.5	12.5	7.41	8
WC	6	10	8	1	9	9	13	11	6	6.5	6	7.77	6
WF	14	1	11	10	3	10	12	4	5	3	2.5	6.86	10
WP	7	14	4	7	11	1.5	1	10	12.5	10	14	8.36	3

	Weighted Indicator Scores												
Site	1	2	3	4a	5	6	7	8	9	10	11	Average	RANK
BE	1.795	0.190	1.187	0.463	0.085	0.695	-	0.295	0.737	0.101	0.489	0.604	12
CP	1.104	1.232	0.254	1.043	1.188	0.253	0.314	0.589	0.968	1.361	0.611	0.811	1
DC	1.657	0.284	0.085	1.622	0.636	0.190	0.549	0.098	1.152	0.504	0.049	0.621	10
DY	0.690	0.853	1.102	0.579	0.170	0.411	0.471	0.884	0.092	0.202	0.293	0.522	14
GL	0.552	0.758	0.848	1.274	0.636	0.411	0.392	1.374	0.645	1.159	0.293	0.759	4
GR	1.243	1.137	0.170	1.506	1.103	0.095	0.235	0.196	1.290	0.655	0.293	0.720	6
HI	1.519	0.569	0.763	0.232	0.509	0.821	0.863	0.785	0.184	0.403	0.122	0.616	11
ME	0.276	0.474	0.509	1.390	1.018	0.884	0.785	1.178	0.830	0.857	0.293	0.772	2
NP	0.138	0.379	1.017	0.348	0.424	0.758	0.628	1.276	0.277	0.857	0.489	0.599	13
SP	1.381	1.043	0.593	0.927	0.339	0.411	0.157	0.491	0.968	1.361	0.489	0.742	5
SS	0.414	0.663	0.424	0.695	0.849	0.411	0.706	0.687	0.369	1.159	0.611	0.635	9
WC	0.828	0.948	0.678	0.116	0.764	0.569	1.020	1.080	0.553	0.655	0.293	0.682	7
WF	1.933	0.095	0.933	1.159	0.255	0.632	0.942	0.393	0.461	0.302	0.122	0.657	8
WP	0.966	1.327	0.339	0.811	0.933	0.095	0.078	0.982	1.152	1.008	0.684	0.761	3

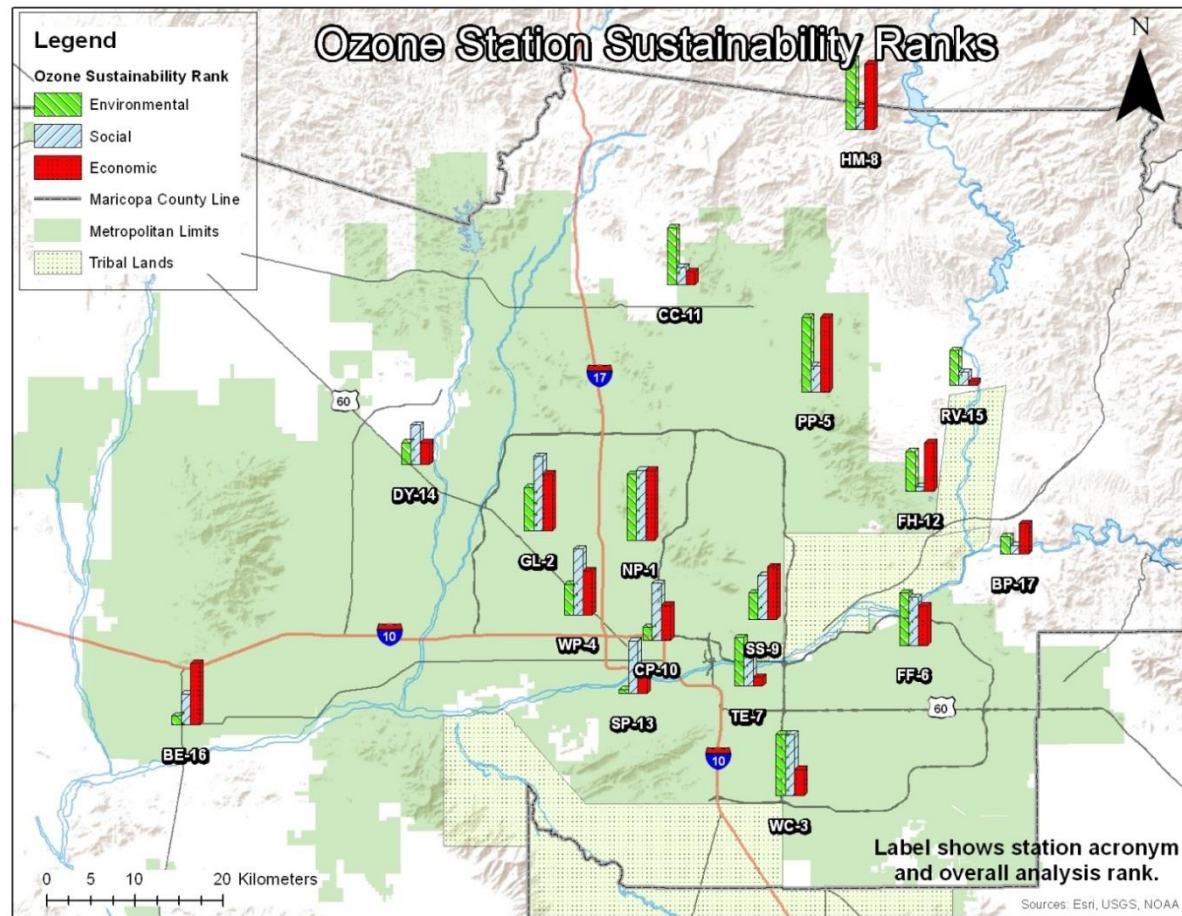
Rank	Unweighted	Weighted
1	CP	CP
2	ME	ME
3	WP	WP
4	GL	GL
5	SP	SP
6	WC	GR
7	GR	WC
8	SS	WF
9	NP	SS
10	WF	DC
11	HI	HI
12	BE	BE
13	DC	NP
14	DY	DY



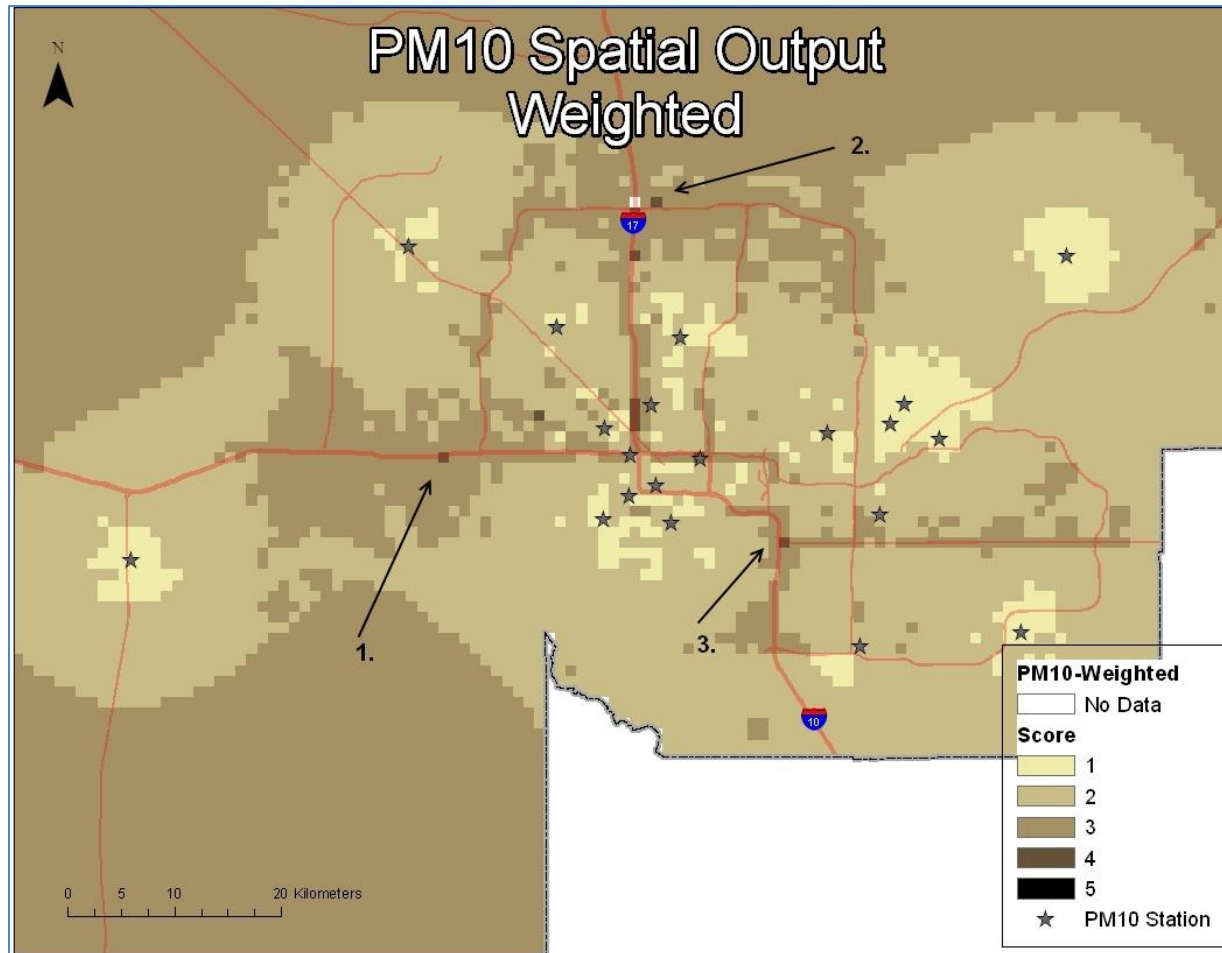
Phase I Results-PM10



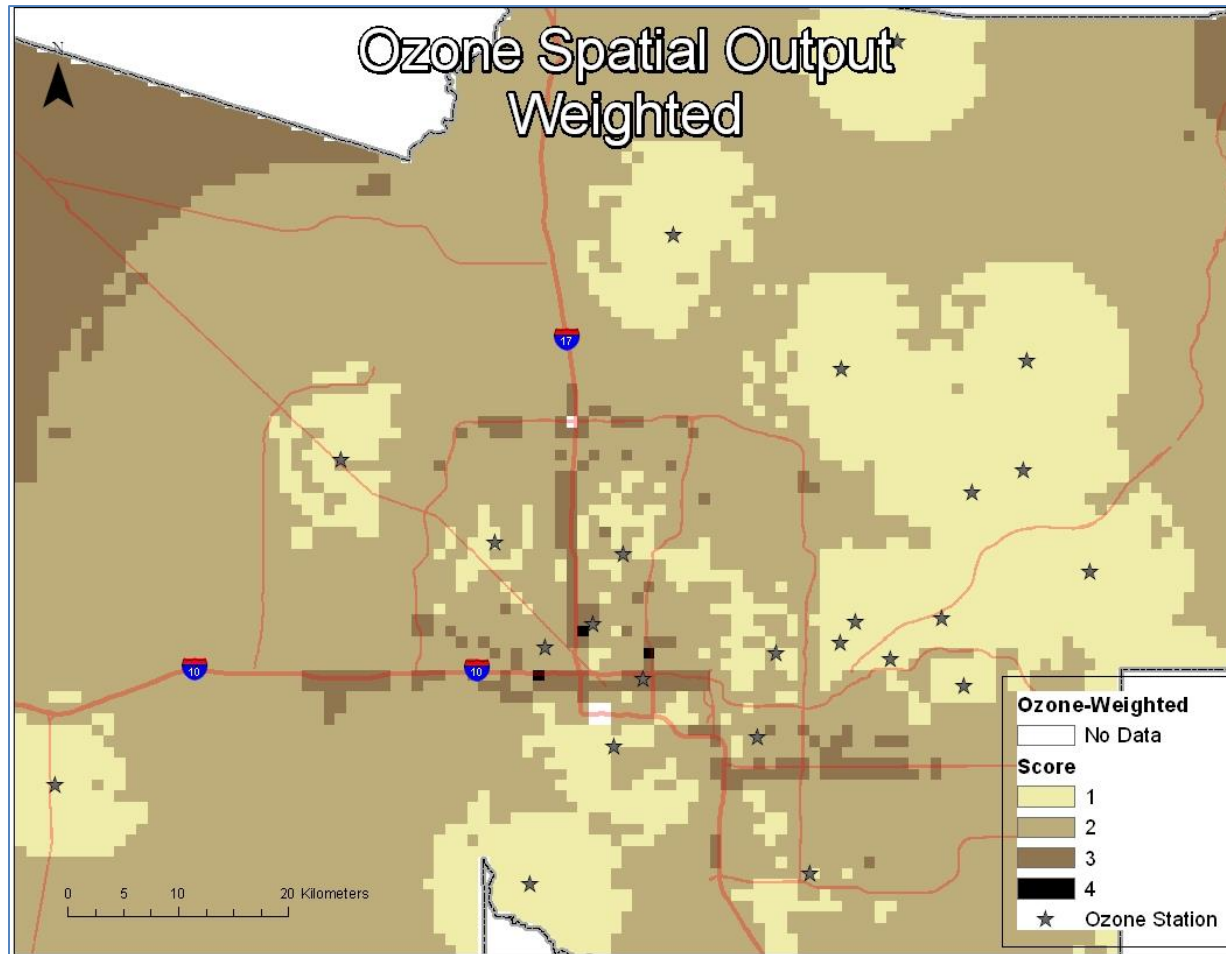
Phase I Results-Ozone



Phase II Results-PM10



Phase II Results-Ozone



Conclusion

- Station Design Objectives
 - Consider the station's objective, it might provide worth outside of the assessment score.
- Recommendations for the Ozone network.
 - No changes recommended, but consider Phase II results if moving sites.
- Recommendation for the PM10 network.
 - New sites recommended, consider redundancy if moving sites.



Conclusion

- What worked?
 - Multiple Indicators for multiple objectives.
 - Sustainability indicators greatly simplified analysis (seeing the big picture).
- What could be improved upon?
 - Improved weights
 - Indicators for additional sources (agriculture, transport, etc.)
- Additional environmental justice indicators.



Questions?

Thank you!

Ronald Pope, PhD



Additional information can be found in the published article:
Journal of the Air & Waste Management Association,
Volume 64, Issue 6, June 2014